IMPACT OF ALCOHOL ADDITION TO FUEL ON THE NOISE LEVEL OF SMALL COMBUSTION ENGINES

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Abstract
Nuisance of small combustion engines' operation with special consideration of engines driving machines designed for work at green areas is discussed in the article. Main hazards connected with noise occurring during their operation have been discussed. The basic problems of bioethanol generation as well as the course and results of the surveys on the impact of ethanol addition to fuel on the noise level at the time of engine's operation depending on the rotational speed is presented in the paper. Occurrence of essential differences between the noise level and the content of ethanol in the operating motor's fuel has been found.

Key words: combustion engines, ethanol, biofuel, noise.

INTRODUCTION

Sound emission accompanies operation of all the machines. Its impact on the comfort of an operator's operation and on the environment (outsiders, wild or farm animals) has been the subject matter of numerous surveys and legal provisions. Even the sources of energy considered to be ecological ones and environment friendly may constitute a threat. It concerns for example wind power plants the impact of which, as mentioned by KARWOWSKA ET AL. (2015), KARWOWSKA ET AL. (2014), MIKOŁAJCZAK ET AL. (2013), has an intensive impact within a sphere of up to 500 m, and extremely unfavourably within the distance of up to 50 m. In case of machines for cutting and shredding, a considerable part of energy generated by the motor is converted into a working element motion resistances not connected with the performed work accompanied by noise emission BOCHAT ET AL. (2013).

Sounds connected with a combustion engine's operation may be used for its technical condition's diagnosing. As mentioned by KOMOROWSKA AND GÓRNICKA (2010), sound intensity within the scope of selected frequencies may determine the technical condition of an engine's elements. Lowering of environmental nuisance for combustion engines is reached at different levels. There may be included design changes reducing both fuel consumption as well as betterment of combustion gases' composition or the use of engine oils on the organic basis what, as mentioned by TULIK ET AL. (2013), may contribute to the decrease of combustion engines' for the environmental nuisance.

Application of bio additives to fuels aims at lowering of fossil fuels' consumption. The surveys of EVANGELOS ET AL. (2013) confirm their beneficial impact most of all on combustion gases' composition, and in case of engines with self-ignition, additional reduction of the volume of solid particles MULEROVA ET AL (2013). However, effective acquiring of both ethanol as well as vegetable oil used as fuel additives has become a problem.

Instability of crude oil's prices together with the necessity to guarantee permanent and safe energy supplies, in the last few decades contributes to the quite rapid increase of biofuels generation. It is anticipated, that the area of farm lands designed for cultivation of plants for energy purposes shall significantly increase only by 2025, and biofuels may then provide about 10% of supply of the world demand for transport fuel KERCKOW (2007).

However, there are more and more negative opinions in the world on production of bioethanol. Oponents of biofuels say, that the increase of bio components' production may pose a threat both for the food prices as well as to contribute to the escalation of competition for farm land designed for cultivation of plants for consumption purposes Production of first generation fuels attributes to many environmental, economic and ethical problems, and its increase leads to the increasing competition of fuels with food and natural factors the resources of which are limited. Insufficient number of surveys assessing the impact of biofuels production on environment causes, that the development of that industry on a big scale becomes risky.

However, the manners of new methods of energy resources' management acquisition are still one of the most important problems influencing the world's economy development.

Biofuels originating from biological raw materials provide, as compared to fossil fuels, many economic and habitat benefits. Bioethanol driving to reduction of greenhouse gases for 31% (through substitution of petrol and diesel oil) has become the most often used fuel in the world. In the union countries, where it is mainly produced from grain crops and sugar beets, the interest in corn being one of the most energetic distiller raw material has been growing.

The researches of GUMIENNA ET AL. (2016), concerning many corn's hybrids have confirmed, that not only the content of starch in corn's grain determines ethanol productivity. Variations of corn of higher starch content have lower saccharification's efficiency, while variations of the highest level of reducing sugar in grains are characterized by higher ethanol productivity. Very high yielding prospects of that species and possibility of corn's cultivation on weaker soils cause, that in the European conditions it becomes, apart from beet, one of the most important raw material for bioethanol production GUMIENNA ET AL. (2014).

The purpose of the conducted surveys was to establish, if in the engines with magneto ignition the addition of ethanol influences the level of noise at different engine speeds.

MATERIALS AND METHODS

The experiment has been planned as a two-factor experiment of 4 levels of the prime factor (content of alcohol in fuel) and 2 levels of the second factor (rotational speed). The experiment factors and their values are presented in Tab. 1.

The researches were conducted for a four-stroke combustion engine, (which can operate in each position 0-360 degrees), overhead valve OHC, air cooled of engine cubic capacity 35,8 cm^3 and power 1,0 kW (1,3 kM). Such an engine is used to drive combustion lawn mowers, aerators and small electric power generators. At the time of measurements, the engine did not drive any machines, before measurements' starting it operated for 30 minutes with maximum rotational speed 733 rad s^{-1} (7000 rpm), at feeding with fuel of octane number 95, without ethanol admixture. In the distance of 0,5 m from the motor's edge, in the axis of crankshaft, the sound level was measured with the use of an integrating sound meter HD 2010 UC. The time of the experiment's conducting was 5 minutes for the rotational speed of the idle running 83 rad s^{-1} (800 rpm) and 5 min for maximum speed 733 rad s^{-1} (7000 rpm). The reading was repeated 5 times after each 45 seconds of operation. The rotational speed was measured with a laser revolution counter Voltcraft DT-10L with measurement precision ±0,5%, according to the manufacturer's data.

Having performed the measurements, the remaining part of the fuel was removed from the tank and a new portion of fuel with ethanol additive (10%) was spilled. The started engine was left on idle running for about 10 minutes, for possible use of the fuel residues in fuel pipes after the previous measurement. The fuel sample no 2 was once again removed from the tank and a new portion of fuel of identical composition was spilled to exclude the impact of the previous type of fuel's impact in the tank and fuel pipes. After 5 minutes of operation and possible correction of the mixtures' composition by changing of the volume of air supplied to the engine,, the next measurement cycle for maximum rotations and then for idle running's rotations was started. There was analogical procedure with the remaining types of fuels.

The composition of the mixture applied in the measurements is presented in Fig. 1.

Tab. 1. – Factors of the experiment and their values

Fuel's composition (factor A)	Rotational speed (factor B)	
	83 rad s^{-1} (800 rpm)	733 rad s^{-1} (7000 rpm)
	100 petrol /0% ethanol	100 petrol /0% ethanol
	90% petrol /10% ethanol	90% petrol /10% ethanol
	75% petrol /25% ethanol	75% petrol /25% ethanol
	60% petrol /40% ethanol	60% petrol /40% ethanol

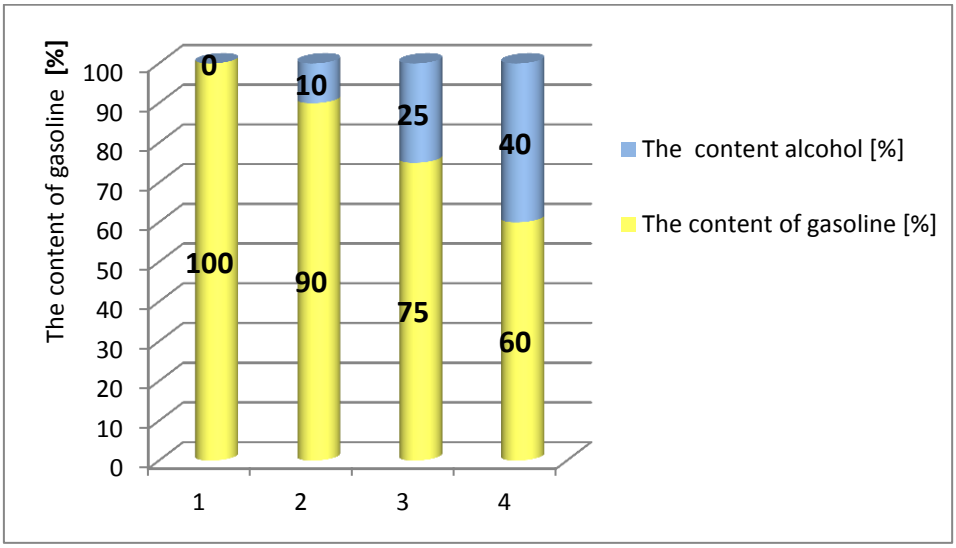

Fig. 1. – Content of alcohol and petrol in the next fuel samples

RESULTS AND DISCUSSION

The results obtained in the experiment are presented in the Tab. 2, then they were subject to statistical analysis for a two-factor experiment with testing of differences' significance applying the Tukey test on the level 0,05. The software FR-ANALWAR on the basis of Excel was used for the analysis.

As a result of the conducted analysis, significance of the value of the sound level for the level of 0,05 for the factor B (rotational speed) and the factor A (content of alcohol in fuel) and A x B interaction was found.

Tab. 2. – Results of volume measurement

Content of petroleum in fuel	Sound level for 83 rad s^{-1} (800 rpm)					Sound level for 733 rad s^{-1} (7000 rpm)				
%	dB(A)					dB(A)				
100	75.4	75.5	75.3	75.8	75.4	93.2	92.7	92.4	91.9	93.2
90	74.1	74.3	74.2	74.3	73.9	89.4	90.1	90.4	90.5	89.4
75	75.1	74.8	73.6	75	73.3	91.5	88.2	88.7	87.8	88.7
60	74.9	74.5	75.6	74.8	74.5	88.9	89.1	88.5	88.3	88.4

For the increasing content of ethanol in fuel already at 10% alcohol additive, the drop of the sound level was found both for the speed 83 rad s^{-1} (800 rpm) as well as for 733 rad s^{-1} (7000 pm). For 83 rad s^{-1} (800 rpm) the highest sound level was found for fuel of 100% petroleum content. An essential difference (drop in sound level) has occurred already at 10% of alcohol addition of fuel, the further increase of alcohol content in fuel did not result in any significant drop in sound level.

The sound level at rotational speed 733 rad s^{-1} (7000 rpm) decreased together with the content of ethanol in fuel. The biggest drop in sound level was noticed in addition of 10% of ethanol, it amounted to 2,72 dB(A). It was only when the content of ethanol in fuel exceeded 25% when no drop of sound level was noticed.

The influence of the factor B (rotational speed) on the sound level is confirmed by many authors. Such a phenomenon is described by EVANGELOS (2016), it concerns both the engines with self-ignition as well as with spark ignition. Similar results were obtained by YASAR (2010), who in spite of application of butyl and methyl alcohol as additives, for both these additives received reduction of the sound level.

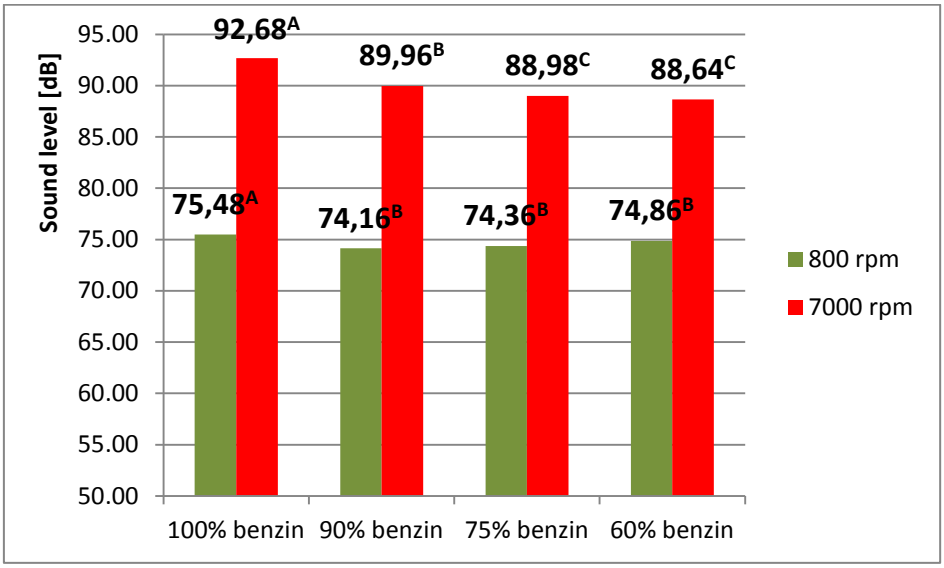

Fig. 2. – Dependency of the sound level on the content of alcohol (factor A) and rotational speed (factor B)

KESKIN (2010) in his surveys also confirmed the statistically significant drop in the noise's level for 1500 and 2500 rpm already for the addition of ethanol 5%. However KESKIN AND GURU (2011) in other surveys found the increase of the noise level for the addition of ethanol 25%, but they conducted these surveys for the variable engine loadings.

This effect may be connected with application of ethanol of octane number 108, much higher than petrol (95). It decreases propensity of detonation's occurring in an engine, in particular in engines without adjustment ignition advance angle. It has been confirmed by JAROMIRO AND DAVID (2013). Kumar AND AGARWAL (2011) draw attention to the fact, that addition of alcohol results in the decrease of pressure in the combustion chamber during the engine's operation. However, Turner at al. suggest, that addition of alcohol to petroleum results in raising of the heat of evaporation what decreases the speed of combustion. During the subsequent surveys, it shall be necessary to assess within which considerable degree, for lowering of the sound level there attributes demand for air for fuel combustion connected with the share of alcohol resulting both in smaller suction murmurs as well as with lower combustion gases volume, and as a consequence – lower noise from exhaust system.

CONCLUSIONS

As a result of the connected experiment it was found, that the additive of ethylene alcohol to petrol influenced lowering of the engine's sound level. The highest drop (for about 2,7 dB(A) of sound level was found at 10% of ethanol addition and engine's rotations 733 rad s^{-1} (7000 rpm). In the realized experiment, addition of alcohol to fuel above 25%, for the rotational speed 733 rad s^{-1} (7000 rpm), it did not result in statistically significant drop in noise's level.

For the engine rotational speed amounting to 83 rad s^{-1} (800 rpm) addition of ethanol above 10% did not result in statistically significant drop in noise's level.

Usage of alcohol as fuel additive may be, apart from betterment of exhaust gases' composition, an additional factor decreasing the noise level for the environment of the combustion engines' operation.

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